Education & Public Outreach

The Laboratory for Terrestrial Physics' Education and Public Outreach Program supports exploration and discoveries of Earth and Planetary Science. The Program is a comprehensive resource for information about research conducted by the Laboratory. It promotes scientific literacy and awareness. The Laboratory's Program aligns with NASA's education objectives to enhance educator knowledge and preparation, develop supplementary curricula, forge new education partnerships and support all levels of students. Several of the Laboratory's premier Educational and Public Outreach projects from 2003 include:

- Web-based Education & Public Outreach

- Support for the GLOBE (Global Learning and Observation to Benefit the Environment) Program

- IMAGERS (Interactive Multimedia Adventures for Grade School Education Using Remote Sensing)

- Landsat 7 Education & Public Outreach

- Earth as Art

- Earth as Parks

- Landsat Data Continuity Mission Education & Public Outreach

- Sensing Cape Cod

LTP Reaches Out Through the Web

The Laboratory for Terrestrial Physics has always maintained a strong presence on the Web. It is an excellent way to communicate information. It is a particularly good tool for informing the public and educators about the science that the Lab conducts in a way that is both understandable and relevant.

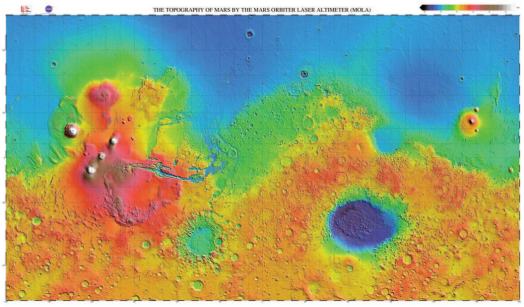
The following are some of the general interest and/or education websites the LTP is involved with:

The LTP Education & Public Outreach Homepage: (http://ltp-education.gsfc.nasa.gov)

The focus of the LTP Education & Public Outreach (EPO) site is the presentation of LTP science in a way that is fun and exciting, primarily through feature articles, interviews with Lab scientists, and imagery. Topics featured in 2003 included how El Niño affects disease in Africa, interviews with members of LTP's international community, the topography of Martian landing sites, and how Geographical Information Systems can be used to help prevent the spread of diseases like malaria.

The Mars Orbiting Laser Altimeter (MOLA) Homepage: (http://mola.gsfc.nasa.gov)

The MOLA homepage is a general interest page that describes the significance of the instrument to the Mars Global Surveyor mission. MOLA data has contributed to mapping of Mars' topography among many other things. A series of articles written about discoveries made using MOLA data is a part of



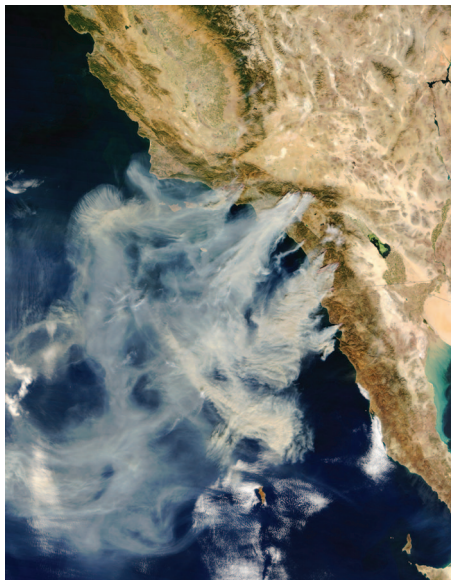
the website; the discoveries range from snow and clouds to craters to the internal structure of Mars.

Figure 1. MOLA Topography Map.

The Geoscience Laser Altimeter System (GLAS) Homepage: (http://glas.gsfc.nasa.gov)

The GLAS homepage is a general interest web page for the Geoscience Laser Altimeter System (GLAS) instrument aboard ICESat. The site describes what laser altimetry is and what GLAS's science goals are.

Moderate Resolution Imaging Spectroradiometer (MODIS): (http://rapidfire.sci.gsfc.nasa.gov and http://modis.gsfc.nasa.gov)



MODIS, is a key instrument aboard the Terra and Aqua spacecrafts. Terra passes over the earth North to South in the morning, and Aqua passes south to north in the afternoon.

Figure 2. MODIS Aqua image of the Southern California Wildfires.

Other signifcant websites are described throughout this report section. They include:

IMAGERS: http://imagers.gsfc.nasa.gov

The Adventures of Echo the Bat: http://imagers.gsfc.nasa.gov/echohome.html

The Adventures of Amelia the Pigeon: http://imagers.gsfc.nasa.gov/amelia/index.html

How Can We Grow Smarter? http://growsmart.gsfc.nasa.gov

Landsat-7 Earth as Art On-line Gallery: http://earthasart.gsfc.nasa.gov

Contact: Maggie Masetti, mmasetti@ltpmail.gsfc.nasa.gov

Highlights from LTP Contributions to the GLOBE Program

The GLOBE Program is a worldwide partnership of K-12 students, teachers, and scientists working together to study and understand the global environment. On June 16, 2003, the University Corporation for Atmospheric Research (UCAR) in partnership with Colorado State University (CSU) was officially awarded a Cooperative Agreement from NASA to assume primary responsibility for development and administration of the GLOBE Program. Internationally, GLOBE is a partnership between the United States and over 105 other countries. More than 1 million primary and secondary students in over 12,000 schools with more than 20,000 GLOBE-trained teachers have taken part in the program, and those numbers continue to grow.

GLOBE students make observations and measurements that have been developed by research scientists on the soils, hydrology, land cover, phenology, and atmosphere at or near their schools. Each GLOBE school also receives a Landsat image of its area which teachers and students use to classify the vegetation type and other characteristics. Students determine the latitude and longitude with GPS and collect other metadata about their study sites. The student data is reported through the Internet to the GLOBE data archive, where it can be used by scientists and student researchers.

As part of the GLOBE project, Dr. Elissa Levine and her team have developed the student protocols and learning activities for soil characterization that are part of the GLOBE Soil Investigation. These were updated in 2003 and are available as part of the Teacher's Guide on the GLOBE web page (www.globe.gov). The team also developed educational materials and web resources, performed trainings and other outreach functions for the education community, and used the GLOBE student data for their Earth science research. In one study, GLOBE student data for soil, atmosphere, land cover, and GPS were used to parameterize and validate a biophysical Earth system simulation model called GAPS (General Purpose Simulation Model of the Atmosphere-Plant-Soil System). Results of this study demonstrated that GLOBE student data provides an important source of input and validation information for simulation models such as GAPS to improve our understanding of the Earth system. A paper describing these results was submitted for publication entitled "Utilizing Satellite Imagery and GLOBE Student Data to Model Soil Dynamics"(Robin, J., E. Levine, and S. Riha). Similar simulations are being performed using data from GLOBE schools in different biomes worldwide.

Other accomplishments from the Soil team during 2003 included the development of Basic GAPS, a student version of the GAPS model, in collaboration with researchers from Cornell University. Like the GAPS model, Basic GAPS simulates the water and energy cycle between the atmosphere, soil, and vegetation. Students can use GLOBE program data and input the information through guided menus. Once the model simulation runs, changes in soil water content, evaporation, transpiration and other environmental parameters can be displayed to allow students to observe how different parts of the system change and are affected by each other (Figures 1 and 2). In this way, students learn how the Earth's ecosystems are the result of closely linked, dynamic interactions among many processes and many components.

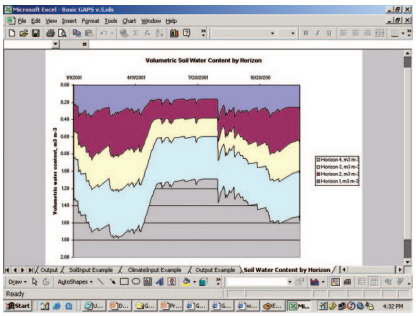


Figure 1. Soil moisture with depth under forest vegetation as simulated by Basic GAPS with GLOBE data.

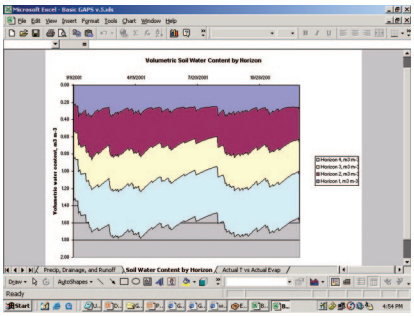


Figure 2. Soil moisture with depth under no vegetation as simulated by Basic GAPS with GLOBE data.

A project to begin in spring of 2004 is GLOBE ONE, the first intensive field campaign involving GLOBE students and scientists. This campaign will take place in Black Hawk County, Iowa, and will be studying the effects of conservation tillage and no-till agricultural practices, as well as natural prairie, on soil, water, and air quality, phenology, and wildlife (hummingbird) habitat.

Dr. Levine will also be involved with a project entitled "Inspiring Blind and Visually Impaired Students with Earth Science". This project is funded by Goddard's Director's Discretionary Fund and will adapt GLOBE protocols to be accessible to blind and visually impaired students.

Contact: Elissa Levine, elissa.levine@nasa.gov

IMAGERS – Educational Program for Grades K-8

IMAGERS (Interactive Multimedia Adventures for Grade-school Education using Remote Sensing) continues to develop as the premier K-8 program for Earth Science. The program takes a creative approach to teach students about remote sensing technology, the electromagnetic spectrum, and false color imagery. Through the context of a literacy-based approach, students are able to comprehend viewing the Earth from above, identify basic land features, and continue on to reading and understanding false color imagery. This interactive web-based product continues to inspire children across the country.

"Echo the Bat" and "Amelia the Pigeon" are products targeted for grades 5-8 and K-4 students, respectively. They introduce and reinforce the science and technology of remote sensing. These products have both an engaging multimedia adventure and a teacher's guide with lessons and activities that bring the concepts back into the classroom. The program engages children while maintaining quality educational value in the classroom.

The "Echo the Bat" program and curriculum support materials have been incorporated into exciting NASA programs such as the new NASA Explorer Schools program. Some Explorer Schools are incorporating "Echo the Bat" into their middle school curriculum. Our involvement on the steering committee of one Explorer School allows the Laboratory to stay involved in the progress and implementation of the Explorer School program.

Another NASA program, JASON, has incorporated portions of the "Echo the Bat" product. JASON has benefited from our product's unique approach to introducing fundamental concepts of remote sensing. Both children and adults have gained a strong understanding of this technology that enables better comprehension of other NASA Earth Science products.

As a result of the successful development of products for NASA, we have gained recognition from other Earth Science Education Programs nationwide. The Digital Library for Earth Science Education (DLESE) has invited us to participate in their working group on "best design practices for Earth science education products." We participate on the advisory board for a $10 million NSF (National Science Foundation) grant being implemented in Baltimore County Maryland Schools. Our knowledge and extensive piloting of educational programs in the Laboratory will help develop models for grades K-8 Earth science education.

Our program has been highlighted at a variety of venues. IMAGERS was showcased at the Maryland Science Center complete with interactive kiosks and activities. The program was also presented at national conferences including those given by the International Technology Educator Association (ITEA) and the National Science Teachers Association (NSTA), as well as to pre-service teachers at Johns Hopkins University and Tennessee State University.

Our products continue to succeed with our NASA peers. Our two new products, "Numbers to Pictures" education brief and the Landsat New York City lithograph, were approved for broad distribution at the May 2003 Earth Science Education Product Review.

The Echo the Bat Puppet Show, given by Ginger Butcher (shown at left) presents satellite imagery to enlighten our next generation of scientists.

Contact: Ginger Butcher, ginger@ltpmail.gsfc.nasa.gov

Landsat 7

The Landsat 7 Education and Public Outreach program targets both formal (classroom) and informal audiences, and involves several different projects in 2003.

Brochure: The Landsat 7 team drafted a 30-page Landsat brochure for Goddard Space Flight Center's Earth Observing System Project Science Office, describing who manages the Landsat program, why and how people use Landsat data, where to obtain data and images, and the program's history and future.

How Can We Grow Smarter?: The team completed the "How Can We Grow Smarter?" Web-based educational resource. The resource provides a template for teachers to use Landsat data, local maps, and aerial photographs for teaching urban change over time. The resource also offers guidance on how to customize the unit to address a rich array of other land use/land cover change issues. It is now published at:

http://growsmart.gsfc.nasa.gov/

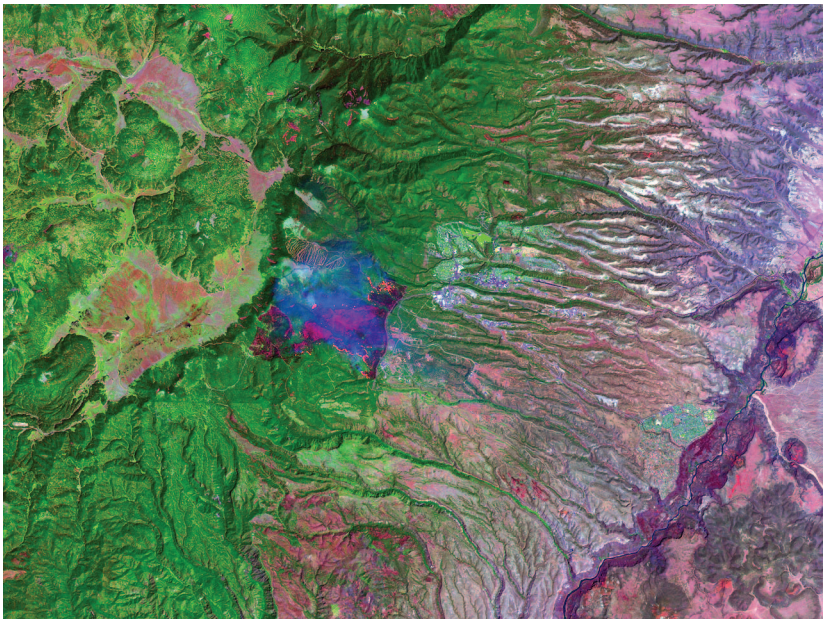
Landsat Training CD: The team developed and piloted the use of a Landsat Training CD for teachers. The CD includes tutorials, data, and exercises about land remote sensing from the Landsat Program, the GLOBE Program, Purdue University, and the Canada Centre for Remote Sensing.

Teacher and Student Workshops: The team conducted workshops for several groups of teachers and students: NASA educators gathered at Langley Research Center; Masters in Education degree students at Johns Hopkins University for their Earth Observation Systems course; Pennsylvania teachers in collaboration with the GSFC Education Office; local area teachers on the classroom activity "Finding Impact Craters with Landsat"; and for Salish-Kootenai Tribal College student interns on MultiSpec software for image analysis.

The GLOBE Program: The team presented a poster at the American Geophysical Union annual meeting, highlighting the Landsat Project Science Office partnership with GLOBE.

USGS Award: Some members of the Education and Public Outreach team received one of the USGS's most prestigious awards, the Shoemaker Award for excellence in outreach activities, for their work with Landsat: Earth as Art.

Two major Education and Public Outreach programs for Landsat 7 are **Earth as Art** and **Earth as Parks**. Please see the following sections of the report for informaton about these projects.



On May 9, 2000, the Landsat 7 satellite acquired an image of the area around Los Alamos, New Mexico, including the Cerro Grande Fire. In this false color image, areas recently burned appear black. Dark red to bright red patches, or linear features within the burned area, are the hottest and possibly actively burning areas of the fire. LTP Education & Outreach Programs enable students and teachers to learn about the applications of Landsat for fire management, estimates of burn severity, and other ecological investigations.

Image by Rob Simmon, Earth Observatory, NASA GSFC. Data courtesy of Randy McKinley, EROS Data Center (EDC).

Contact: Stephanie Stockman, Stephanie.A.Stockman.1@gsfc.nasa.gov

Earth As Art

The Earth As Art exhibit was initiated by the USGS EROS Data Center (http://edc.usgs.gov/) to commemorate the 30th Anniversary of the Landsat program. Initially, 41 Landsat-7 satellite images of different areas of the world were created out of visible and infrared data in colors visible to the human eye. The images were chosen on the basis of aesthetic appeal, and the band combinations and colors were chosen to optimize their dramatic appearance.

Last year, these images were displayed in several locations and an on-line gallery to showcase them was created.

The Landsat: Earth as Art exhibit has continued to evoke strong interest and to open doors for the Landsat Program in 2003.

The Landsat 7 team collaborated with the GSFC Education Office to develop activities based on Earth as Art for NASA Explorer School teachers. (NASA Explorer Schools receive special attention and funding from NASA for a three-year period.) The activities engage students in learning about how wetlands, volcanoes, glaciers, and other land forms appear when observed by Landsat. Each of the Explorer Schools has received a set of five posters reflecting five "spheres" of Earth system science (hydrosphere, geosphere, atmosphere, cryosphere, and biosphere).

The Landsat: Earth as Art exhibit was placed at the New Mexico Museum of Natural History and Science, in Albuquerque, NM, from August 2003 through January 2004. That exhibit period included Albuquerque's annual Balloon Festival. The city experienced unusual rain storms during the Festival, which sent more visitors than usual to the Museum, and to appreciate Earth as Art.

The Landsat: Earth as Art collection is on long-term display at NASA Headquarters, the GSFC Visitor Center, and the Library of Congress. The Library of Congress's Geography and Map Division personnel have observed so much interest in the exhibit by U.S. Congressional Staff that they have kept it far longer than anticipated. The interest has been not only in the stunning images but also in the information about the Landsat Program itself.

Visit the Online Earth as Art Gallery:
http://landsat.gsfc.nasa.gov/earthasart/

Figure 1. Great Sandy Scars, Australia. In a small corner of the vast Great Sandy Desert in Western Australia, large sand dunes --the only sand in this desert of scrub and rock -- appear as lines stretching from left to right. The light-colored fan shapes are scars from wildfires.

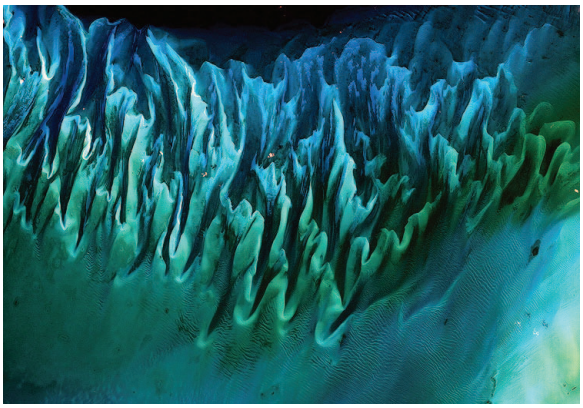


Figure 2. Ocean Sand, Bahamas. Though the above image may resemble a new age painting straight out of an art gallery in Venice Beach, California, it is in fact a satellite image of the sands and seaweed in the Bahamas. The image was taken by the Enhanced Thematic Mapper plus (ETM+) instrument aboard the Landsat 7 satellite. Tides and ocean currents in the Bahamas sculpted the sand and seaweed beds into these multicolored, fluted patterns in much the same way that winds sculpted the vast sand dunes in the Sahara Desert.

Contact: Jeannie Allen, Jeannette.E.Allen.1@gsfc.nasa.gov

Earth as Parks

Earth as Parks (EaP), a web-based interactive exhibit currently under development, will showcase the use of a variety of mapping techniques - from historical hand-drawn maps to more current maps derived from space-based sattelite observations.

Working together with the Library of Congress and USGS throughout 2003, the Landsat 7 Education & Public Outreach team began a pilot project in two National Parks: Acadia National Park and Shenandoah National Park. The interactive online exhibits will use cultural and historical themes to introduce the public to the utility of remote sensing for both national park appreciation and management. A variety of land cover media will be employed: historical maps, topographic maps, aerial photographs, and Landsat imagery. Each "panel" of the online exhibit will represent land use/land cover at a different time period. EaP also takes advantage of the Library of Congress's existing digitized maps, and builds on a close relationship the team has developed with the U.S. National Park Service (NPS).

At Shenandoah National Park, Big Meadows has been chosen by the NPS to represent the constant, complex interplay between natural forces and human influences that change and shape the landscape over time. Big Meadows is the only substantial clearing in the park, and a popular destination for travelers along Skyline Drive. NPS hopes the online exhibit will convey a sense of the various forces acting on Big Meadows for long-term change, and to convey the fact that NPS must take action based on difficult decisions about how to manage the site so that both cultural and natural resources are protected. Big Meadows has been the subject of intensive research by paleoclimatologists, hydrologists, archeologists, fire ecologists, mammalogists, and botanists, and so presents rich opportunities for interpretation to the public.

At Acadia National Park, the story will focus on how people have impacted, and been impacted by, the landscape of Mount Desert Island for thousands of years.

People have long relied upon the natural resources of the island for their sustenance and their livelihood. The logging, damming of streams to power mills, and grazing of salt marshes has faded. In their place is intense recreational use of these same natural resources. Millions of people visit Acadia every year to be spiritually and physically refreshed through immersion in the spectacular landscape of mountains, streams, forests and sea. Many of these people are so in love with the area, that acres of land are now being consumed in a building boom just outside park boundaries. People are now concerned about loss of habitat, and degradation of the character of the island.

As human impact on landscapes has increased, so has our understanding about those impacts. Our sensitivities to the values inherent in a landscape approach to land management have increased, and science has taught us much about how to live lightly on the land. EaP will help people to examine landscape change over time in both of these parks, through active manipulation of graphical elements in the on-line exhibits.

Figure 1. Landsat image of Maine coast, including Mount Desert Island, site of Acadia National Park.

Evaluation is also an important aspect of Earth as Parks. The Landsat E/PO team has engaged a professional evaluator and plans to take lessons learned to collaborations with other national parks.

Contact: Anita Davis, Anita.L.Davis.1@gsfc.nasa.gov

Landsat Data Continuity Mission Education & Public Outreach

The NASA Landsat Data Continuity Mission (LDCM) Education and Public Outreach (EPO) is aimed at formal and informal education communities across the Nation. In 2003, the program included cooperative efforts with NASA and USGS Landsat 7 projects, as well as independent activities. Areas of emphasis included work with the Salish-Kootenai Tribal College in Montana, with the National Park Service at Cape Cod National Seashore (Sensing Cape Cod), and at the Chesapeake Bay Gateways Network. Some education activities were deferred, pending a decision regarding the Request for Proposal for the LDCM Implementation Phase.

Conferences:

LDCM created and staffed a booth for the National Association for Interpretation's annual National Interpreter's Workshop. Over 1200 professional interpreters (park rangers, nature center, museum and science center staff, etc.) were in attendance. The booth focused on the uses of remote sensing science and imagery for conveying concepts to natural and cultural site visitors. Two framed Earth as Art posters donated by USGS received much attention at the annual scholarship auction.

In conjunction with USGS, LDCM and Landsat produced and staffed a booth at the Partnerships in Stewardship Conference, a meeting of the nation's land management agencies. Over 1000 of the top managers of the nation's land management agencies and their partners were in attendance. The booth aimed to inform the audience about the uses of Landsat and remote sensing for resource management decision-making.

Grants:

LDCM provided a grant to Salish-Kootenai College (the only four-year tribal college in Montana), for three graduate level student internships at Goddard. For three weeks in summer of 2003, three students received intensive training in remote sensing, GIS and applications of remote sensing to their area of graduate work. The effort also included expansion of training given at the college level specifically targeted at Native American working professionals. The project was successful, and a continuation of this work is expected in coming years.

LDCM funded a grant to initiate outreach to the more than 120 sites associated with the Chesapeake Bay Gateways Network. The intent of the project was to provide imagery and science linked to compelling stories of the Bay, in a fashion that would be useful to the staff at these various sites. Meetings were held with the Gateway Network leads in the National Park service, training was provided to key personnel, and a small exhibit produced for the first Gateways Network conference. These meetings were attended by personnel from the majority of the network sites. Research and development continue.

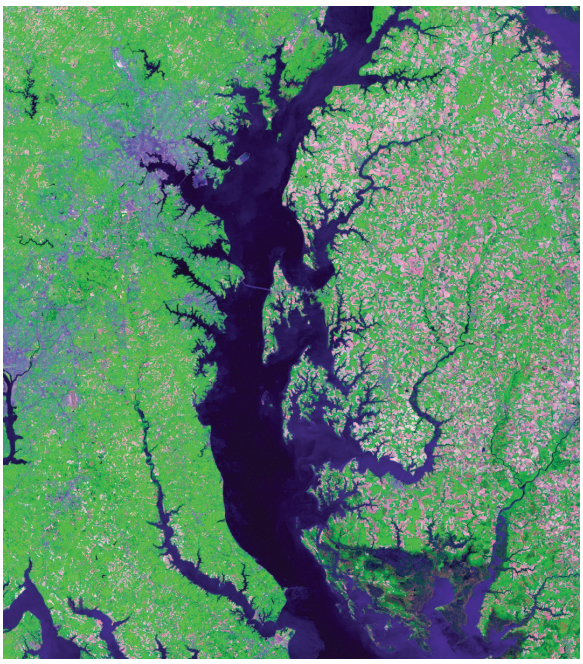


Figure 1. Landsat 7 image of the Chesapeake Bay.

LDCM also contributed funds and staff time towards Sensing Cape Cod, a pilot project incorporating remote sensing in curriculum-based programming at Cape Cod National Seashore. (Please see article on page 101.)

Contact: Anita Davis, Anita.L.Davis.1@gsfc.nasa.gov

Sensing Cape Cod

Sensing Cape Cod is a middle and high school level coastal ecosystem curriculum unit under development, that uses remote-sensing data and ground reference protocols to monitor ecological change at the local scale. Connections between the responses of local coastal ecosystems to environmental processes and human activities will be made, so that teachers and students will have a greater understanding of Earth system science as it applies to Cape Cod National Seashore (CACO), a unit of the National Park System.

Figure 1. This image of Cape Cod, Massachusetts was taken from the Landsat 7 satellite on Sept. 18, 1999. The Cape Cod National Seashore covers the eastern part of the "hook" of the Cape facing the Atlantic Ocean, and some areas facing Cape Cod Bay (inside).

Students will use satellite images to examine four ecosystems at the National Seashore before and after they collect ground-based data. The study will help determine how Cape Cod has changed and is changing over time due to natural and human causes. Students will also use data from National Oceanic and Atmospheric Administration buoys; digital cameras on the ground and on-board remote controlled airplanes and small aircraft; and hand-held Alta Spectrometers.

It is expected that some 9,000 students will be reached in the initial stages of the project. The project will expand as teachers establish study sites in their own individual communities. The lesson plans will also extend to classes outside the current group. Because CACO is a prototype park for other coastal parks, the plan is to include participation from other National Parks, and in the final phase all findings will be posted on the Internet for public use.

2003 was the second year of this 3-year project, and marked the beginning of direct involvement of the Landsat Data Continuity Mission (LDCM). LDCM provided extensive educational resources, drawing upon existing Landsat and other remote sensing educational products; LDCM also donated several processed Landsat scenes and data sets of the park; and provided technical assistance as needed.

LDCM also coordinated involvement from other members of the NASA family for a series of workshops held to train a team of local science teachers in Earth system science, remote sensing, and technology for use in development of the lesson plans. Aerospace Education Specialist Suzanne Kinneson visited the team several times, Dr. Elissa Levine (NASA/GSFC) taught about soils, and educators from the CALIPSO and CloudSat missions instructed teachers in air quality, and how to use a sun photometer. Dr. Debbie Krumm (GLOBE science program manager) provided an introduction to the GLOBE program. During the summer, lesson plans were created for the field components of the project. Final curriculum units will actively tie in remote sensing activities.

Other project partners include the USGS, the Boston Museum of Science, the Audubon Society, the U.S. Fish and Wildlife Service, and the Massachusetts Marine Educators Association (who ensured consistency with national science standards). The collaboration between CACO and NASA began in 2002 with a grant from the National Park Foundation made possible through the support of the PG&E National Energy Group. The Earth Science Enterprise provided technical guidance in early stages of project development.

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Acknowledgements

The Laboratory for Terrestrial Physics would like to recognize its members and collaborators for their hard work and accomplishments. This report is proof of the outstanding work they do.

We'd like to thank the Goddard, national, and international communities for their contributions and collaborations with us. We'd like to especially recognize the Massachusetts Institute of Technology (MIT), Scripps Institute of Oceanography, the University of Maryland (UMD) College Park and Baltimore Campuses, and the Earth Resources Observation Systems (EROS) Data Center (EDC) for their collaborative efforts.

We would like to thank all who took time from their busy schedules to contribute to this report. Our thanks also go out to the Branch and Office secretaries and administrators.

Thanks to Maggie Masetti who organized, compiled, formatted, edited, and did the layout of the report. Thanks also go to Charlie Schnetzler for organzing the publications and editing the text of the report, and to Marcia Doran for proofreading it.

Appendix 1 - Acronyms

AERONET	Aerosol Robotic Network
ALI	Advanced Land Imager
APD	Avalanche PhotoDiode
APL	Applied Physics Lab
AVHRR	Advanced Very High Resolution Radiometer
BARC	Beltsville Agricultural Research Center
BioSAR	Biological Synthetic Aperture Radar
BKG	Bundesamt fuer Kartographie und Geodaesie
BSDF	Bi-directional Scatter Distribution Function
BRDF	Bi-directional Reflectance Distribution Function
CCD	Charged Coupled Device
CCRS	Canadian Center for Remote Sensing
CDDIS	Crustal Dynamics Data Information System
CF	Calibration Facility
CIESIN	Center for International Earth Science and Information Network
CHAMP	CHAllenging Mini-Satellite Payload
CMB	Core-Mantle Boundary
DAAC	Distributed Active Archive Center
DCaF	Diffuser Calibration Facility
DFB	Distributed FeedBack
DLR	Deutsche Zentram Fur Luftund Raumfahrt
DMSP/OLS	Defense Meteorological Satellite Program Operation Linescan System
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DSN	Deep Space Network
ECCO	Estimating the Circulation and Climate of the Ocean
EDC	EROS Data Center
EDFA	Erbium Doped Fiber Amplifier
ENSO	El Niño Southern Oscillation
ENVISAT	ENVIronmental SATellite
EO-1	Earth Observing One (satellite)
EOP/PC	Empirical Orthogonal Functions/Principal Component
EOS	Earth Observing System
EPSCoR	Experimental Program to Stimulate Competitive Research
EROS	Earth Resources Observing System
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESE	Earth Science Enterprise
ESSP	Earth System Science Pathfinder
ETM +	Enhanced Thematic Mapper Plus
FAME	Full-sky Astrometric Mapping Explorer
FWHM	Full Width Half Maximum
GFO	GEOSAT Follow-On
GGFC	Goddard Geophysical Fluids Center
GIMMS	Global Inventory Mapping and Monitoring Studies
GIS	Geographic Information System
GLAS	Geoscience Laser Altimeter System
GLONASS	Global'naya Navigatsionnay Sputnikovaya Sistema (Global Navigation Satellite System)
GOFC/GOLD	Global Observation of Forest and Land Cover Dynamics
GPS	Global Positioning System
GRACE	Gravity Recovery And Climate Experiment
GSFC	Goddard Space Flight Center
HSI	HyperSpectral Imager

IAG	International Association of Geodesy
IDS	International DORIS Service
IEEE	Institute of Electric & Electronics Engineers
IERS	International Earth Rotation Service
IGS	International GPS Service
ILRS	International Laser Ranging Service
INDOEX	Indian Ocean Experiment
IVS	International VLBI Service for Geodesy and Astrometry
JIVE	Joint Institute for VLBI in Europe
KTP	Potassium (K) Titanate (Ti) Phosphate (P)
KVN	Korean VLBI Network
LAI	Leaf Area Index
LBA	Large-Scale Biosphere-Atmosphere Experiment in Amazonia
LCLUC	Land-Cover Land-Use Change
LDCM	Landsat Data Continuity Mission
LDOPE	Land Data Operational Product Evaluation
LEO	Low Earth Orbiter
LLR	Lunar Laser Ranging
LTP	Laboratory for Terrestrial Physics
MBLA	Multi Beam Laser Altimeter
MCST	MODIS Characterization Support Team
MFF	Medusae Fossae Formation
MGS	Mars Global Surveyor
MISR	Multi-angle Imaging SpectroRadiometer
MLA	Mercury Laser Altimeter
MLL	Mixed Layer Lidar
MOBLAS	Mobile Laser Ranging Stations
MOC	Mars Orbiter Camera
MODAPS	MODIS Adaptive Processing System
MODIS	Moderate Resolution Imaging Spectroradiometer
MOPITT	Measurements Of Pollution In The Troposphere
MOSST	MOdular, Scalable, Self-consistent, Three-dimensional
MPIR	Max Planck Institute for Radioastronomy
NCEP	National Center for Environmental Predictions
NDVI	Normalized Difference Vegetation Index
NEIGE	NetLander Ionospheric and Geodesic Experiment
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NRAO	National Radio Astronomy Observatory
NRL	Naval Research Laboratory
NTIA	National Telecommunications and Information Administration
OCO	Orbiting Carbon Observatory
OMI	Ozone Measuring Instrument
ORNL	Oak Ridge National Lab
POD	Precision Orbit Determination
PRIDE	Puerto Rico Dust Experiment
RAID	Redundant Array of Inexpensive Disk
RASL	Raman Airborne Spectroscopic Lidar
RVF	Rift Valley Fever
SAFARI	Southern Africa Regional Science Initiative
SAVE	Southern Africa Validation of EOS
SAR	Synthetic Aperture Radar
SeaWifs	Sea-viewing Wide Field-of-view Sensor
SDP	Scientific Data Purchase

SLA	Shuttle Laser Altimeter
SLR	Satellite Laser Ranging
SNR	Signal to Noise Ratio
SOI	Southern Oscillation Index
STARSHINE	Student Tracked Atmospheric Research Satellite for Heuristic International Networking Experiment
STRI	Smithsonian Tropical Research Institute
TEC	Total Electron Content
TOPEX	TOPography EXperiment
TOMS	Total Ozone Mapping Spectrometer
TRF	Terrestrial Reference Frame
USDA	United States Department of Agriculture
UNFAO	United Nations Food and Agriculture Organization
USGCRP	U.S. Global Change Research Program
USNO	United States Naval Observatory
USUHS	Uniformed Services University of the Health Sciences
VCL	Vegetation Canopy Lidar
VHF	Very High Frequency
VLBI	Very Long Baseline Interferometry

Appendix 2 - Grants, Contracts, Co-operative Agreements

The Laboratory for Terrestrial Physics has many efforts that involve sources of information, areas of study, and co-operations housed within, and external to, the physical confines of the Laboratory.

Grants are generally established with colleges and universities. The Laboratory has established grants or contracts totaling nearly $19.4M with 61 institutions of higher education. Among those institutions involved are:

University of Alabama
University of Alaska
University of Alaska, Fairbanks
University of Albany
American University
University of Arizona
Austin College
Boston University
California Institute of Technology
University of California, Berkeley
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Colorado, Boulder
Regents of the University of Colorado
Columbia University
Cornell University
Dartmouth College
Florida International University
University of South Florida
Harvard University
University of Hawaii
Henry Jackson Foundation
Southern Illinois University
University of Maryland, Baltimore Campus
University of Maryland, College Park
Massachusetts Institute of Technology
University of Massachusetts
University of Memphis
University of Miami
University of Michigan
Michigan Technological University
University of Montana
University of North Carolina
Morgan State University
National Oceanic Atmospheric Administration (NOAA/NESDIS)
University of Nevada, Reno
University of New Hampshire
State University of New York
Northwestern University
Ohio State University
Oregon State University

University of Pittsburgh
University of Puerto Rico
Rochester Institute
Salish Kootenai College
Universidad Nacional de San Agustin
Smithsonian Astrophysical Observatory
South Dakota State University
Southwest Research Institute
Stanford University
Stevens Institute of Technology
Texas A&U
University of Texas, Austin
University of Washington
Central Washington University
University of Wisconsin, Madison
U.S. Environmental Protection Agency
Woods Hole Oceanographic Institution

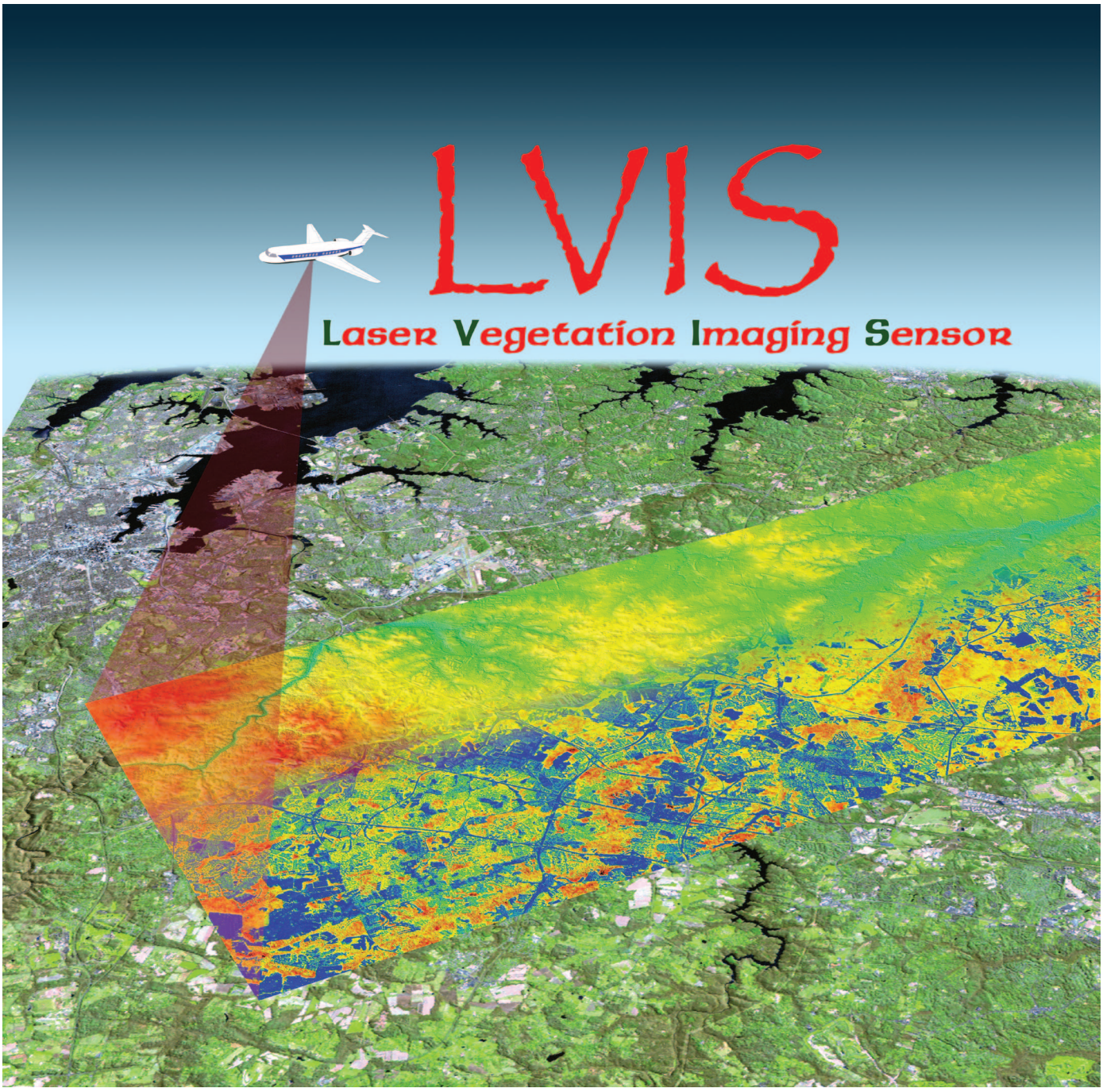
The Laboratory is responsible for grants with 1 commercial industries:

AER, Inc.

The Laboratory holds cooperative agreements with 24 institutions:

U.S. Department of Agriculture
University of Arizona
University of California, Irvine
California State University, Monterey Bay
University of California, Santa Barbara
Cornell University
Harvard University
Indiana State University
State University of New York, Albany
University of North Carolina
University of North Carolina, Chapel Hill
University of Maryland, Baltimore Campus (JCET)
University of Maryland, Baltimore Campus (GEST)
University of Maryland, College Park Campus
Colorado State University
Carnegie Institute of Washington
Marine Biological Laboratory
Michigan State University
Smithsonian Tropical Research Institute
U.S. Geological Survey
University of Utah
University of Washington
University of Wisconsin, Madison
Woods Hole Oceanographic Institution

Additionally, performance-based contracts are held with a number of commercial service providers. Among these are: General Sciences Corporation, Honeywell Technology Solutions, NVI, Raytheon, Science Systems & Applications, Inc., and Sigma Research.



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